Studying Levels of ^{15}F by ^{14}O + p Elastic Resonance Scattering with BEARS

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^{15}F has been of nuclear structure interest, such as predictions of energy levels of T_z = -3/2 nuclides, Thomas-Ehrman shifts across the T=3/2 multiplet [1] and the disappearance of magic number effects due to unbalanced neutron-proton ratios. ^{15}F has been studied earlier with ^{20}Ne(^{3}He, ^{8}Li)^{15}F by Benenson et al [2] and by Kekelis et al [3] in the seventies. Only two levels have been observed so far, the ground state (g.s.) and the first excited state (1st e.s.). Due to the unbound nuclear structure of ^{15}F and the low cross section of about 1-4 μb for producing ^{15}F via ^{20}Ne(^{3}He, ^{8}Li)^{15}F, the level and width of the ground state of ^{15}F had a large uncertainty. Therefore, nuclear reactions with higher cross sections and different reaction mechanisms are of interest for measurement of the energy levels of ^{15}F. Elastic resonance scattering reaction of ^{14}O with protons is one among these. The cross section is high, up to 1000 mb. The mechanism is relatively simple and easy to interpret.

The recently developed Berkeley Experiments with Accelerated Radioactive Species (BEARS) provides a radioactive beam of ^{14}O up to 3×10^4 particles per second on target. This proton rich beam extends the ability to explore nuclei at or beyond the proton dripline. After development of this beam, ^{14}O+p → ^{15}F has been measured using a silicon telescope (72μm ΔE and 3000μm E detectors) placed at 0° and a 200 μm polyethylene target via thick target elastic resonance scattering. Before the actual ^{14}O+p → ^{15}F measurement, the telescope was calibrated using protons from ^{14}N + p.

Since the first successful delivery of ^{14}O as a radioactive ion beam, several ^{14}O+p runs have been performed. Excellent energy calibration can be obtained via the results from ^{14}N+p, and inverse kinematics to normal kinematics. The energy correction differences between ^{14}N+p and ^{14}O+p and the stopping power function have been evaluated for better energy calibration. After careful calibration, the energy levels of ^{15}F were fitted with R-matrix codes. The result is shown in Figure 1. A comparison with other work [2-7] is listed in Table 1.

Our results agree well with Goldberg et al [7] for both the g.s. and the 1st e.s. All the 1st e.s. measurements except Lepine-Szily et al [5] agree with each other. Our g.s. also agrees well with Kekelis et al [3], marginally agrees with Lepine-Szily et al [5], and is quiet different with Benenson et al [2] and Peters et al [6]. Possible causes of these differences may be different resonance definitions and different models to extract the theoretical parameters from the experimental data.

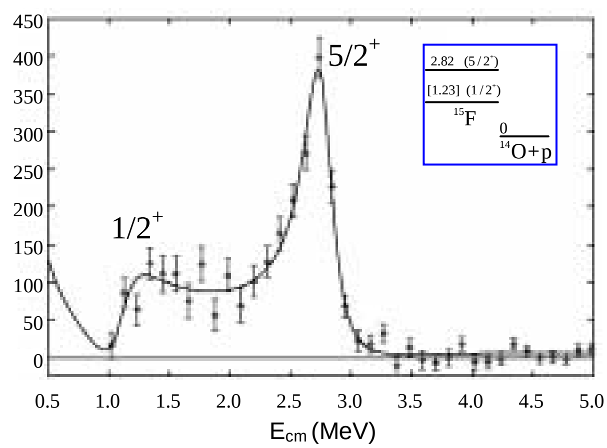

FIG. 1: The R-matrix fit (solid line) of the experimental data (diamond dots) for ^{14}O+p→^{15}F. The negative counts are due to background subtraction.

TABLE 1: Results for the Energy levels of ^{15}F

Level	J^π; T	Ref.	E_x (MeV)	$\Gamma_{c.m.}$ (MeV)
g.s.	$1/2^+$; 3/2	[2]	1.6±0.2	≥0.9
		[3]	1.37±0.18	0.8±0.3
		[4] *	1.2	0.5
		[5]	1.41±0.15	0.8±0.3
		[6]	1.51±0.15	1.2
		[7]	$1.29^{+0.08}_{-0.06}$	0.7
			1.23±0.06 †	
1st e.s.	$5/2^+$; 3/2	[2]	2.8±0.2	0.24±0.03
		[3]	2.67±0.1	0.5±0.2
		[4] *	2.4	0.2
		[5]	2.54±0.07	0.27±0.07
		[6]	2.853±0.045	0.34
		[7]	2.795±0.045	0.325±0.06
			2.82±0.03 †	0.30±0.06 †

* Theoretical estimation. † This work (preliminary).

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